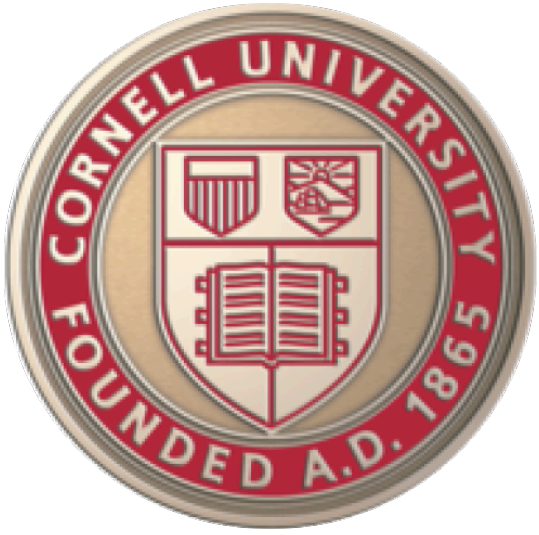
MPA Professional Report

Analyzing the Relationship Between Production and Consumption Diversity in Rural India



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Abstract

While much of the current literature on nutrition emphasizes consumption diversity of diets, lesser empirical research is available on production side of diversity. This study seeks to explore any potential relationship between the household consumption and production diversity in rural India. While consumption diversity is measured by individual and household diet diversity scores measured using guidelines from the Food and Agricultural Organization of the UN, production diversity is measured by developing a production diversity index with a similar methodology as the diet diversity score. The study finds no significant relationship between the production and consumption diversity indexes, and discusses other possible variables that might affect the two indexes.

1. Introduction

The relationship between agricultural production and nutrition has recently gained a lot of interest, given the dismal forecasts, as lower growth rates of food production, are coupled with an increasing global population (see Fig 1 and 2).[1]

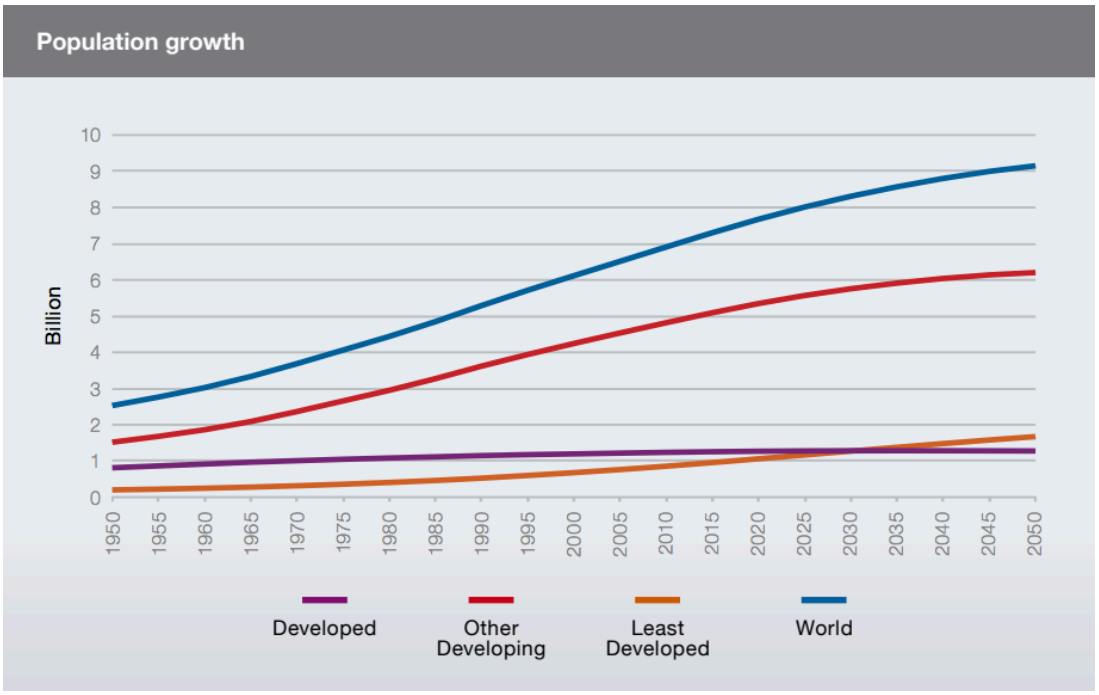

Fig. 1: Population Growth Forecast (Source- FAO)

[1] FAO, "The State of Food Security and Nutrition in the World," 2017, http://www.fao.org/3/a-I7695e.pdf.

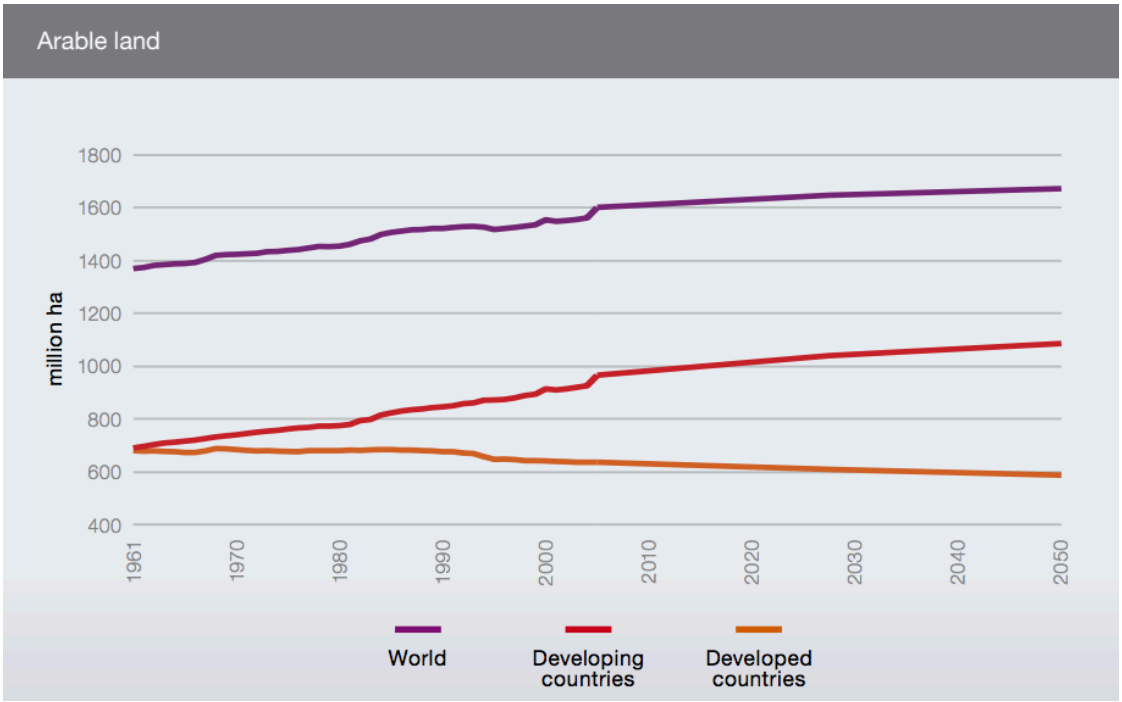

Fig. 2: Arable Land Forecast (Source- FAO)

On the one hand, undernutrition and low diet diversity are causing high prevalence of stunting and wasting in children, and leading to poor maternal and child health outcomes.[2] [3] On the other hand, small holder production is more focused on staple grains than other micronutrients. Especially after the green revolution, small holder production in some developing countries have increasingly grown staple crops.[4] As a result, the food insecure sections of the population belonging to lower socio-economic statuses, with lesser access to markets are the worst affected

[2] K Sibhatu, V Krishna, and M Qaim, "Production Diversity and Dietary Diversity in Smallholder Farm Households," *PNAS (Proceedings of the National Academy of Sciences of the United States of America)*, 2015, http://www.pnas.org/content/112/34/10657?ijkey=dbbebee49fe4e12f49514154706f85e0c82af119&keytype2=tf_ipsecsha.

[3] Stefan Koppmair, Menale Kassie, and Matin Qaim, "Farm Production, Market Access and Dietary Diversity in Malawi," *Public Health Nutrition*, February 2017, https://doi.org/10.1017/S1368980016002135 PMCID: PMC5244442.

[4] Priyadarshani, "Rise of Productivity of Crops after the Green Revolution," n.d., http://www.yourarticlelibrary.com/green-revolution/rise-of-productivity-of-crops-after-the-green-revolution/44589.

by a diet composed of inexpensive staples, rather than more expensive foods such as dairy, meat and micronutrient rich vegetables and crops.[5] Given that small holder farmers are more involved in subsistence farming and consume most of what they produce, it is often assumed that diversifying small-holder production would lead to better nutrition outcomes. However, evidence from existing literature is mixed and does not provide any strong association between diversifying production and improved nutrition outcomes.[6] Some studies suggest that there is a potential bias in only highlighting positive or significant associations. Other studies have insignificant estimates for proclaimed positive associations.

This paper uses household-level data from rural India, to assess any potential relations between diet diversity and production diversity. The data used is from a baseline survey rolled out by the Technical Assistance for Indian Nutrition and Agriculture (TARINA), a project initiated by the Tata-Cornell Institute. The data spans across 3600 households in the Indian states of Bihar, Uttar Pradesh and Odisha (see Figure 3), and was collected in the summer of 2017.

[5] NITI Ayog, "Evaluation Study on Role of Public Distribution System in Shaping Household and Nutritional Security India" (Government of India, 2016), http://niti.gov.in/writereaddata/files/document_publication/Final%20PDS%20Report-new.pdf.
[6] Sibhatu, Krishna, and Qaim, "Production Diversity and Dietary Diversity in Smallholder Farm Households."

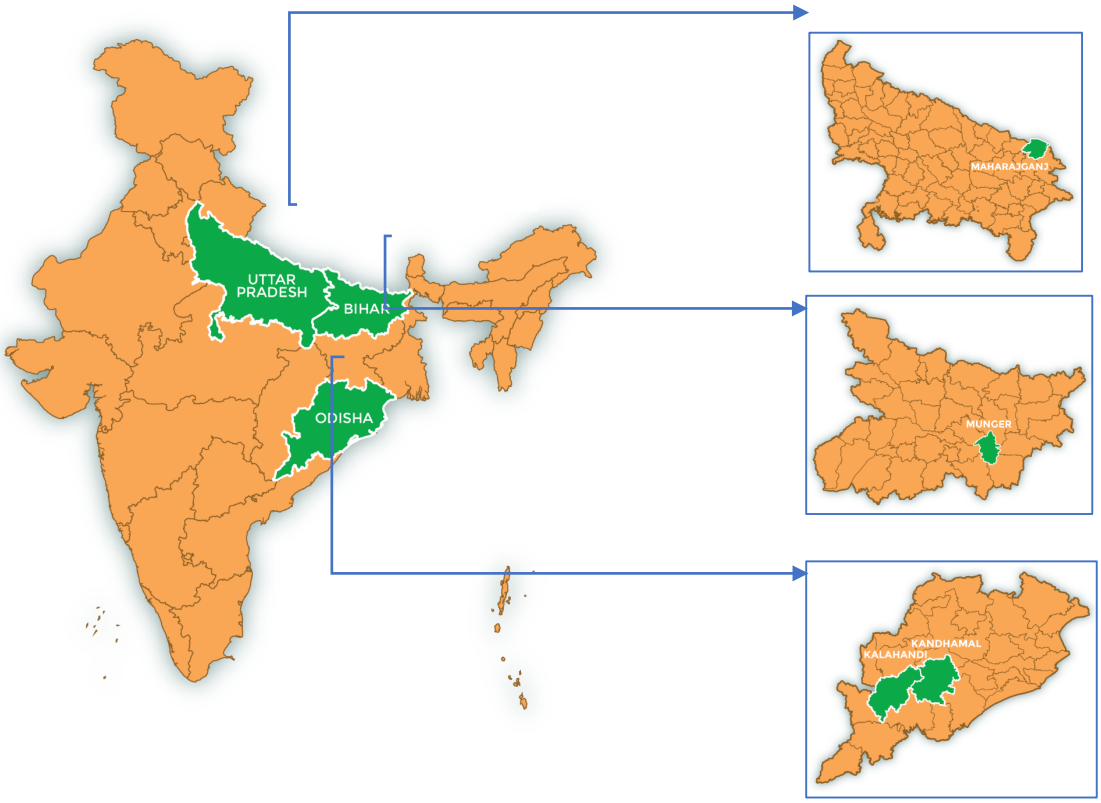

Fig. 3: TARINA States and Districts

This paper seeks to analyze whether diversity in production of food is in anyway associated with diet diversity. It is divided into the following three sections; the first will explore methodology of calculating the consumption diversity index, and the results from the given data. The second section will elaborate on the methodology of creating the production diversity index, its results and limitations. The final section will seek to explore any potential relationship between the results of the two indexes, and aim to explain any unexpected patterns in the results.

2. Consumption Diversity

Context

A diverse diet is one that ensures an adequate intake of micronutrients along with the minimum calorie requirements for an individual. A diet deficient in essential vitamins and minerals such as Iron, Vitamin A can lead to micronutrient malnutrition, both in children and adults. Nutritional outcomes are influenced not only by the intake of a nutritious diet, but also a conducive environment that that enhances the absorption of nutrients.[7] However, other factors such as household access to nutritious food, along with intra-household allocation of the food especially among women and children are also equally important. The following figure, based on the 4-quadrant model discussed by Pingali and Sunder [8] elaborates the complex relationship between diet diversity and nutritional outcomes.

[7] Prabhu Pingali and Naveen Sunder, "Transitioning Toward Nutrition-Sensitive Food Systems in Developing Countries," *Annual Review of Resource Economics*, 2017, https://doi.org/10.1146/annurev-resource-100516-053552.
[8] Pingali and Sunder.

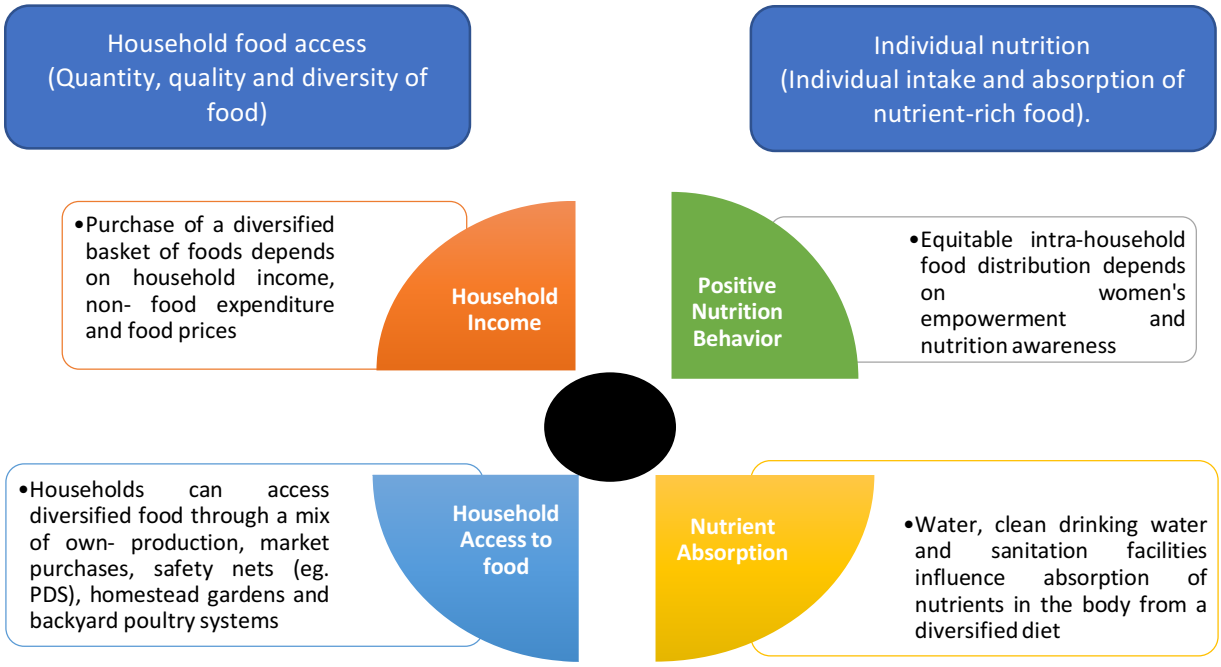

Fig. 4: Dietary Diversity and Nutritional Outcomes

While it is not the only factor affecting food security, household income is positively associated with household food security as it determines the affordability of food.[9] For instance, conditional cash transfer programs such as PROGRESA, Mexico have proven to be successful in improving the conditions of lower socio-economic classes.[10] However, along with household income,

[9] Eileen Kennedy and Pauline Peters, "Household Food Security and Child Nutrition: The Interaction of Income and Gender of Household Head," *World Development*, August 1992, https://doi.org/https://doi.org/10.1016/0305-750X(92)90001-C.

[10] Leigh Gantner, "PROGRESA: An Integrated Approach to Poverty Alleviation in Mexico," in *Food Policy for Developing Countries*, ed. Pinstrup-Andersen and Fuzhi Cheng, n.d., https://cip.cornell.edu/DPubS?service=UI&version=1.0&verb=Display&handle=dns.gfs/1200428168.

demographic characteristics of the population, the household's expenditure on non-food items and prices of food items also determines the basket of food purchased by the household.[11]

Household's access to food depends on the availability of diverse foods in markets, own-production, implementation of safety nets, homestead gardens and livestock owned.[12] An example of safety net model in India is the Public Distribution System (PDS), whereby people living under the poverty line can buy staples at a lesser price than the market price. However, one of the criticisms of the PDS is that because it focuses on selling only staple grains, poorer households do not have access to other micronutrient-rich foods at affordable prices.[13]

Positive nutrition behavior is also important for individual intake of diversified diets. Households are often not aware of the importance of diet diversity. Further, certain cultural practices regarding food allocation can discriminate against women in awareness about nutrition. For instance, in some regions women tend to eat last and consume smaller portions than their male counterparts, leading to a gender bias in their diets.[14] Therefore, awareness on nutrition and the importance of women empowerment, through behavior change communication can lead towards positive nutrition behavior.

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[11] John Hoddinott and Michelle Adato, eds., *Conditional Cash Transfers in Latin America*, n.d.
[12] Koppmair, Kassie, and Qaim, "Farm Production, Market Access and Dietary Diversity in Malawi."
[13] NITI Ayog, "Evaluation Study on Role of Public Distribution System in Shaping Household and Nutritional Security India."
[14] L. Haddad, John Hoddinott, and H. Alderman, *Intrahousehold Resource Allocation in Developing Countries: Models, Methods and Policies*, 1997.

Lastly, an environment conducive to nutrient absorption is also necessary for maintaining a diversified diet.[15] [16] A clean hygienic environment includes access to and usage of clean drinking water, and availability and usage of sanitation facilities. If the household does not have access to a hygienic environment, its members are prone to infection. As a result, the nutrients consumed are utilized for fighting infection instead of growth in children and maintenance of good health in adults.[17]

The Government of India recently launched the National Nutrition Mission (POSHAN Abhiyan), in order to strengthen nutrition-improvement projects, including behavior change communication, incorporating technology in improving management of nutrition programs, and bettering coverage and quality of Integrated Child Development Services, over a 3-year period.[18]

Methodology

One way to calculate the consumption diversity of households is by computing the diet diversity score for an individual or a household, as per FAO guidelines. The score is simply a total count of the number of food groups consumed by a target population over a given recall period. This study

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[15] AT Merchant et al., "Water and Sanitation Associated with Improved Child Growth," *European Journal of Clinical Nutrition*, 2003, https://www.ircwash.org/sites/default/files/Merchant-2003-Water.pdf.

[16] G Fink, I Gunther, and K Hill, "The Effect of Water and Sanitation on Child Health: Evidence from the Demographic and Health Surveys 1986–2007," *INTERNATIONAL JOURNAL OF EPIDEMIOLOGY*, 2011, https://academic.oup.com/ije/article/40/5/1196/658066.

[17] Fink, Gunther, and Hill.

[18] "India, World Bank Sign USD 200 Million Loan Deal for National Nutrition Mission," *Economic Times*, 2018, https://economictimes.indiatimes.com/news/economy/finance/india-world-bank-sign-usd-200-million-loan-deal-for-national-nutrition-mission/articleshow/64069271.cms.

uses the Minimum Dietary Diversity for Women Score (MDDW) and the Household Dietary Diversity Score (HHDS), based on FAO recommended food groups, which add up to a total score of 10 and 11 respectively (see Table 1).

Food Groups for Minimum Dietary Diversity for Women	Food Groups for Household Diet Diversity
1. Grains, white roots and tubers, and plantains	1. Root and tubers
2. Pulses (beans, peas and lentils)	2. Pulses/legumes/nuts
3. Nuts and seeds	3. Cereals
4. Dairy	4. Milk and milk products
5. Meat, poultry and fish	5. Meat/Fish
6. Eggs	6. Eggs
7. Dark green leafy vegetables	7. Vegetables
8. Other vitamin A-rich fruits and vegetables	8. Fruits
9. Other vegetables	9. Oil/fats
10. Other fruits	10. Sweets
	11. Spices/ beverages

Table 1: Food Groups for computing Dietary Diversity Scores

Results

While the average MDDW across the four districts in the sample is 4 out of 10, the average HHDS is 6 out of 11 (see Fig. 3 and 4). This implies that an average woman consumes 4 food groups as compared to 6 groups consumed by a household. Further, while Kandhamal, Odisha had the

highest MDDW of 6.3 out of 10, Munger, Uttar Pradesh has the highest HDDS of 6.3 out of 11. However, at the same time, Munger has the lowest MDDW at 3.9 out of 10.

This reveals a possible gender bias in the two scores which shows that even though a household might be consuming a more diverse diet as a whole, the women in the household might not have equitable access to all food groups available in a household. This points to a larger socio-economic issue of gender norms within intra-household allocation of food. However, it should be kept in mind that the scores are measured on different scales, which is why direct comparison can be misleading and does not necessarily explain the gender-bias.

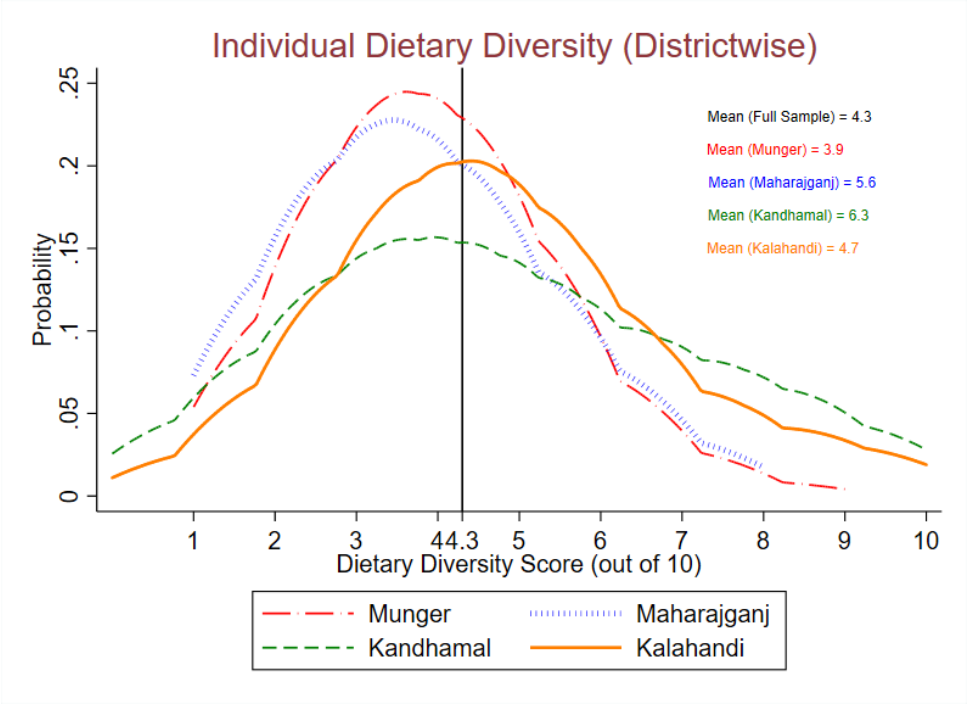

Fig. 5: Distribution of Individual Diet Diversity

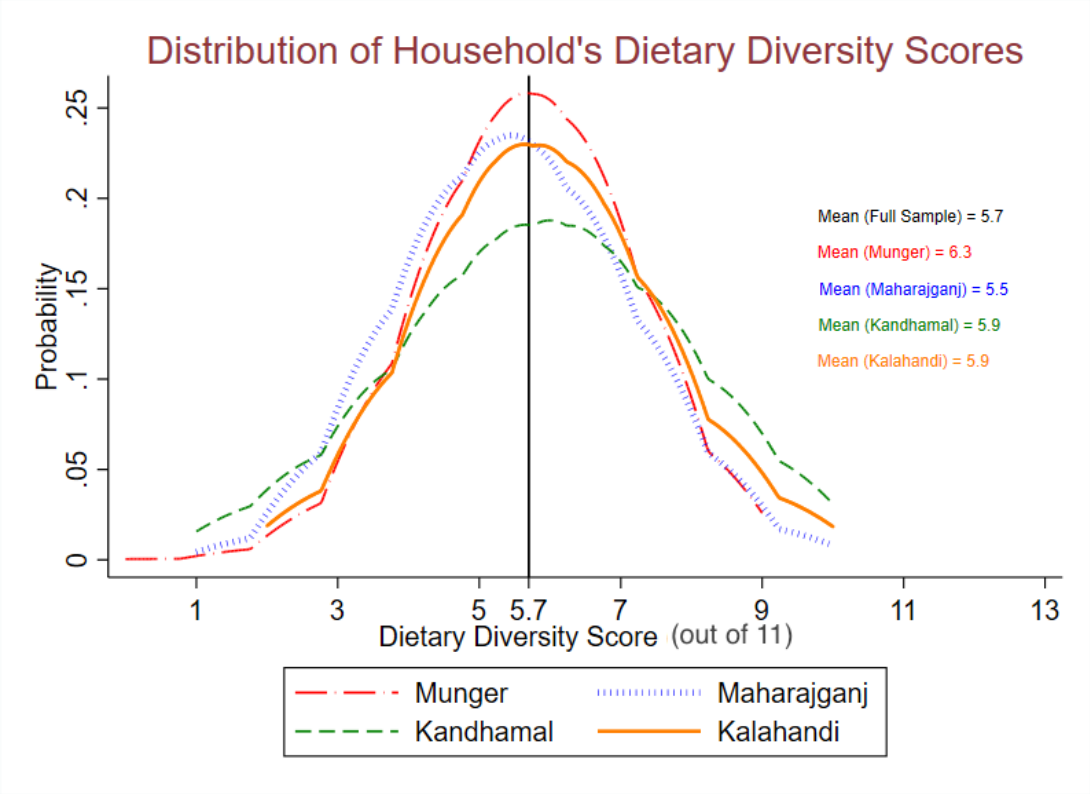

Fig. 6: Distribution of Household Diet Diversity

Limitations

While the diet diversity scores provide an insightful perspective on the status of nutrition in rural India, there are certain measurement errors associated with it. According to the FAO guidelines, the different number of food groups used to calculate MDDW and HDDS makes it harder to compare an individual's diet diversity with that of a household. Further, the data collected based on a 24-hour recall, does not account for day-to-day, or seasonal, variations in consumptions of foods. There is also no information on the quantity of food groups consumed, as well as food consumed outside the house.

3. Production Diversity

While there is a lot of literature on the importance of diversification of diets, relatively lesser research has been conducted regarding diversification of production. Production diversity is of high relevance because of the nature of subsistence-farming in most rural areas in developing countries. Consequently, a large part of what is being consumed in a household is derived from what is being produced in the same household. This is the reason for the common assumption that nutritional diet diversity is reliant on production diversity.[19] Production diversity includes the diversification of crop cultivation in a household, as well as the production of animal source foods of livestock owned by the household. For the purposes of this study, a production diversity index was created to facilitate comparison between the diet diversity and production diversity.

Methodology

The FAO guidelines for diet diversity index divide food groups into 11 categories. As an analog, I used the following 9 of the 11 categories, based on available data, to calculate the Production Diversity Index (PDI), at the household level.

[19] Sibhatu, Krishna, and Qaim, "Production Diversity and Dietary Diversity in Smallholder Farm Households."

Food Groups for Minimum Dietary Diversity for Women	Food Groups for Household Diet Diversity	Food Groups for Household Production Diversity
1. Grains, white roots and tubers, and plantains	1. Root and tubers	1. White roots and tubers
2. Pulses (beans, peas and lentils)	2. Pulses/legumes/nuts	2. Pulses/legumes
3. Nuts and seeds	3. Cereals	3. Cereals
4. Dairy	4. Milk and milk products	4. Milk and milk products
5. Meat, poultry and fish	5. Meat/Fish	5. Meat/Poultry
6. Eggs	6. Eggs	6. Eggs
7. Dark green leafy vegetables	7. Vegetables	7. Green leafy vegetables
8. Other vitamin A-rich fruits and vegetables	8. Fruits	8. Other vegetables
9. Other vegetables	9. Oil/fats	9. Oil/fats
10. Other fruits	10. Sweets	
	11. Spices/ beverages	

To calculate the index, I used a 2-step process, combining data for crop cultivation as well as livestock owned. For the first step, I aggregated the data for crops across 3 seasons (Kharif, Rabi and Zaid). For the first 6 food groups, I used data under 'Crop Cultivation and Crop Use' to categorize the crops produced by the household into first 6 food groups mentioned above. However, some households produced the same crop in multiple seasons, which might have led to double-counting, and some households produced more than one crop in one season. I

adjusted for both of these errors, dropped the duplicates, and arrived at an initial index for each household based on the number of food groups it produces.

Then, I used livestock owned by the households. More specifically, I used data under 'Animal Source Foods' that revealed if the livestock owned by households produced the last 3 food groups mentioned in the list above. However, this section did not include 'Fish', therefore in comparison with the FAO food group Meat/Fish/Poultry, my category only included Meat/Poultry.

Lastly, I combined the two datasets and created a column *pdi_total* as the sum of the 2 sub-indexes, i.e.:

$$pdi_{total} = \sum_{n=1}^{6} pdi_{crop} + \sum_{n=1}^{3} pdi_{asf}$$

Results

The district-wise results of the PDI are summarized in Figure 7. Unsurprisingly, on average, most households are only producing one food group annually, with an average PDI of 1.35 out of 9. While households in Maharajganj, Uttar Pradesh tend to produce more diverse food groups with an average of 1.54 out of 9, those in Kandhamal, Odisha, produce least diverse foods at 1.11. Overall, the production diversity seems to be low across all four districts.

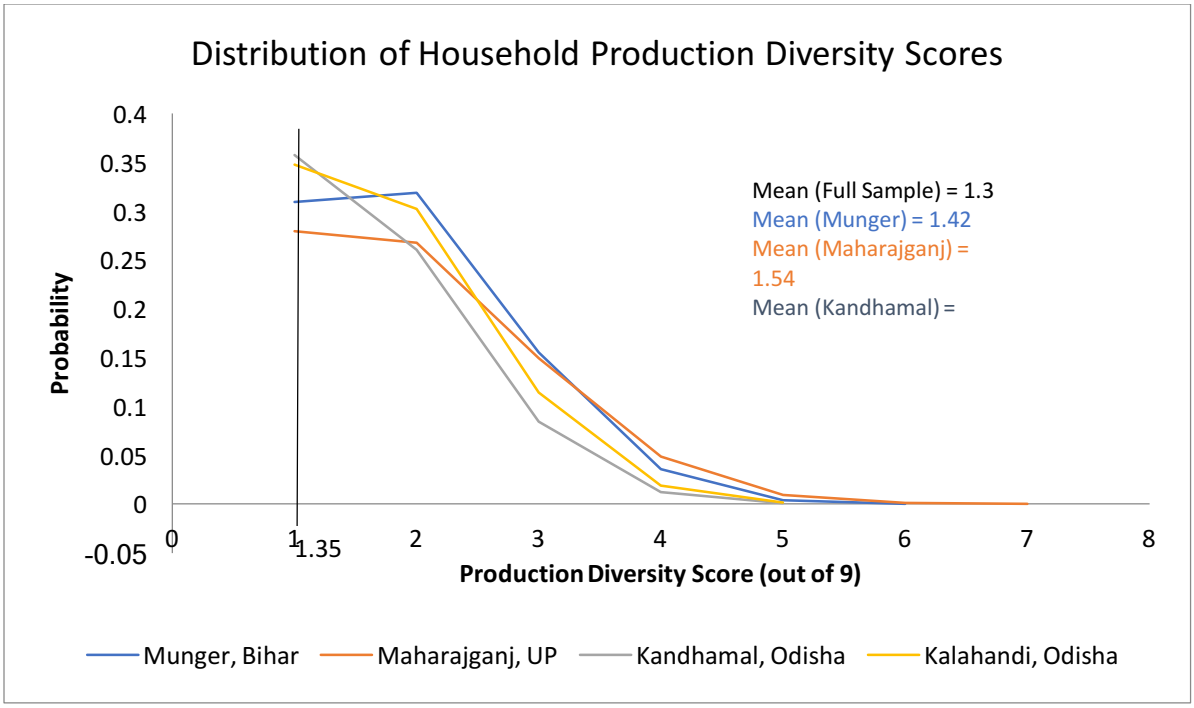

Fig. 7: Distribution of Household Production Diversity

An interesting observation is that despite taking into consideration the three different seasons of crop cultivation, the production diversity still remains low. This implies that even if the households are cultivating in all 3 seasons, there is a high likelihood of growing the same crop throughout the year.

Limitations

The diversity of production in households is not only limited to the choice of crop production or livestock owned, but also other geographic constraints such as climate and topography of the

region, and economic and physical constraints with respect to access to seeds.[20] Further, this approach only takes into account 9 food groups, which makes it harder to compare it to the household diet diversity index, which is measured out of 11. Additionally, some smallholders produce crops or take care of livestock in plots other than their own land. This analysis does not take into consideration rented plots, or home-gardens, thereby missing on crops cultivated on these additional sources of land, and potentially understating the household production diversity.

[20] Roseline Remans et al., "Expanding the View on the Production and Dietary Diversity Link: Scale, Function, and Change over Time," *PNAS (Proceedings of the National Academy of Sciences of the United States of America)*, 2015, http://www.pnas.org/content/112/45/E6082.

4. Analyzing the Relationship between Consumption and Production Diversity

The results obtained from the given dataset do not reveal any significant association between the consumption and production diversity indexes. While Munger, Bihar has the highest household diet diversity score, Maharajganj, UP has the highest production diversity score. Counter-intuitively, despite the highest PDI, Maharajganj also has the lowest HHDS, which points towards bias in the analysis. From Fig. 8, it seems that there is an ambiguous relationship between the production and diet diversities in the four districts. However, this might be due to multiple reasons. First and foremost, the small sample and consequently, lesser data points, reduce the validity of the results. Secondly, there are several other factors (discussed below) that are not captured in a univariate analysis of the two variables.

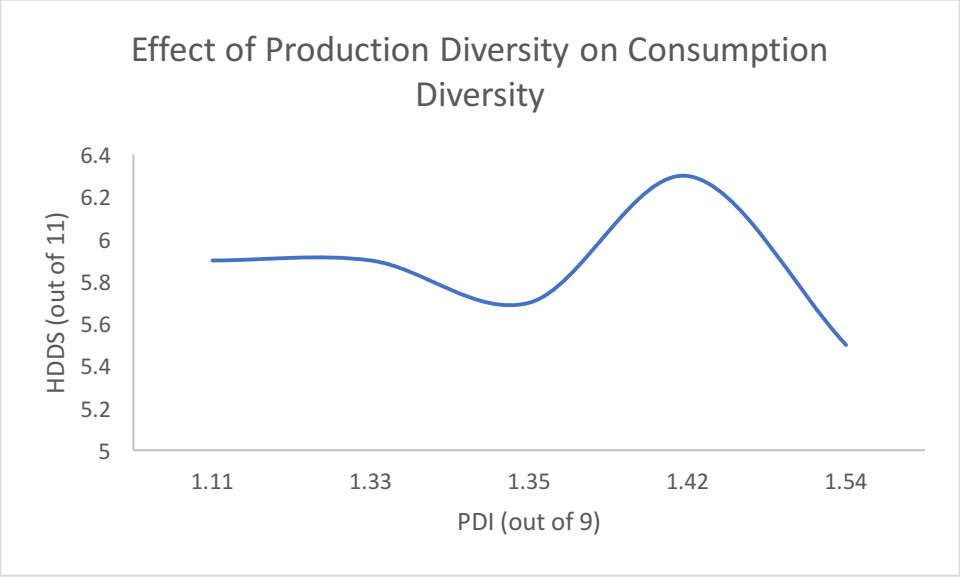

Fig. 8: Ambiguous Relationship between Production and Consumption Diversity

Possible Mechanisms Affecting the Relationship between Production and Consumption

Market Diversity

The assumption that households of smallholder farmers rely entirely on subsistence farming, and do not engage in market transactions oversimplifies the effect of production diversity on consumption diversity. A recent meta-analysis conducted on the relationship between production and consumption diversities in Indonesia, Kenya, Ethiopia and Malawi reveals that lower production diversity is not indicative of a lower consumption diversity, as sufficient income enables households to purchase food from the market. Further, while farm diversification may contribute to household income to a certain point, it may eventually lead to a reduction in income due to foregone benefits of specializing and comparative advantage.[21]

However, while market diversity might seem like an attractive option to enhance consumption diversity, a study conducted in Malawi concluded that regions with the lowest nutritional diversity are those where market-driven solutions are least likely to succeed due to their remote location.[22] While purchased foods contributed more to household diversity than home-grown foods, households further from roads and populations (rather intuitively) gathered more of their food from home production than markets. In the same study, it was found that proximity to

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[21] Sibhatu, Krishna, and Qaim, "Production Diversity and Dietary Diversity in Smallholder Farm Households."

[22] Brian Luckett et al., "Application of the Nutrition Functional Diversity Indicator to Assess Food System Contributions to Dietary Diversity and Sustainable Diets of Malawian Households," *Public Health Nutrition*, 2015, https://www.cambridge.org/core/services/aop-cambridge-core/content/view/C6F17560F8FCA83FC49BEDFEA107EEF4/S136898001500169Xa.pdf/application_of_the_nutrition_functional_diversity_indicator_to_assess_food_system_contributions_to_dietary_diversity_and_sustainable_diets_of_malawian_households.pdf.

extension services in remote locations has significant impact on increasing nutritional diversity not only in consumption, but also in production.

Landscape Diversity

Lower production diversity however, is not the only factor affecting diet diversity. Remans et. al argue that market diversity, landscape diversity and remote settings, all play a role in affecting consumption diversity. With a change in transition of landscape from subsistence agriculture to commercial agriculture, low-income regions might be more likely to export nutritious crops, while importing either staples or highly processed foods that are not ideal for human consumption. The study also highlights the importance of measuring production diversity at a sub-national level instead of household level. However, it is important to consider contextual differences while comparing countries at different stages of economic growth.

5. Conclusion

This study aimed to explore the relationship between production and consumption diversity indexes, computed at the household level, across four districts in rural India. The scores were calculated by simple computation of the number of food groups produced or consumed by a household, based on FAO guidelines.

With a sample of 3600 rural households, the relationship between the production diversity index and the consumption diversity score at the household-level shows no significant pattern, rendering an ambiguous relationship between the two. Even though preliminary evidence might lead one to the assumption that production diversity is associated with consumption diversity, a more in-depth analysis reveals that the relationship between the two is more complex. Even while taking into account all three seasons of production, the average production diversity index across the four districts was only a 1.35 out of 9, while the average diet diversity score was 5.7 out of 11.

In order to gauge the effect of production diversity on consumption diversity, other factors such as the geographic location of the population, landscape of agriculture, as well as markets should also be considered. Additionally, controlling for demographic characteristics, and variances in regional diets will also yield a more robust estimate of the relationship. Further research is needed on quantifying the impacts of each of these factors on diet diversity, and any other potential variables that play a role in analyzing the relationship between consumption and production diversity.

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